Global Hydrology Resource Center

# Data User Guide

# *GPM Ground Validation UND Citation Navigation Data IPHEx*

## Introduction

The GPM Ground Validation UND Citation Navigation Data IPHEx dataset supplies navigation data collected by the Cessna Citation II aircraft for flights that occurred during March 6, 2014 through June 13, 2014 for the Global Precipitation Measurement Ground Validation Integrated Precipitation and Hydrology Experiment (IPHEx) field campaign in North Carolina. The goal of IPHEx was to evaluate the accuracy of satellite precipitation measurements and use the collected data for hydrology models in the region. The Cessna Citation II Research aircraft, owned and operated by the University of North Dakota (UND), participated in the IPHEx field campaign by serving as an in situ microphysics sampling platform. This navigation dataset consists of final processed files containing records that include flight time, aircraft location (latitude, longitude, and altitude), air temperature, wind speed, and other relevant aircraft parameters in ASCII format.

**Notice:** There is one file per UND Citation aircraft flight. Since flights do not occur on a regular basis during the field campaign, there are missing days between March 6, 2014 and June 13, 2014.

## Citation

Poellot, Michael R. 2015. GPM Ground Validation UND Citation Navigation Data IPHEx [indicate subset used]. Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A.
doi: http://dx.doi.org/10.5067/GPMGV/IPHEX/NAV/DATA/001

## Keywords

*NASA, GHRC, GPM GV, IPHEx, North Carolina, UND Citation II, navigation data, upper air temperature, upper level winds, airspeed, ground speed, altitude, pressure, temperature*

## Campaign

The Global Precipitation Measurement mission Ground Validation (GPM GV) campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch of the GPM Core Satellite, which launched on February 27, 2014. The instrument validation effort included numerous GPM-specific and joint agency/international external field campaigns, using state of the art cloud and precipitation observational infrastructure (polarimetric radars, profilers, rain gauges, and disdrometers). These field campaigns accounted for the majority of the effort and resources expended by GPM GV mission. More information about the GPM GV mission is available at the PMM Ground Validation webpage.

One of the GPM GV field campaigns was the Integrated Precipitation and Hydrology Experiment (IPHEx) which was held in North Carolina during 2014 with an intense study period from May 1 to June 15, 2014. The goal of IPHEx was to characterize warm season orographic precipitation regimes and the relationship between precipitation regimes and hydrologic processes in regions of complex terrain. The IPHEx campaign was a part of the development, evaluation, and improvement of remote-sensing precipitation algorithms in support of the GPM mission through NASA GPM GV field campaign (IPHEX_GVFC) and the evaluation of Quantitative Precipitation Estimation (QPE) products for hydrologic forecasting and water resource applications in the Upper Tennessee, Catawba-Santee, Yadkin-Pee Dee, and Savannah river basins (IPHEX-HAP, H4SE). The NOAA Hydrometeorology Testbed (HTM) has synergy with this project. More information about the IPHEx campaign is available at IPHEx Field Campaign webpage.

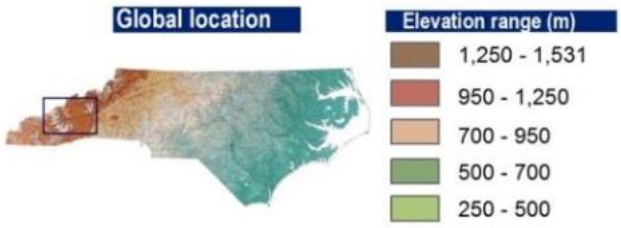


Figure 1: Region of North Carolina IPHEx campaign ground validation (image source: http://gpm-gv.gsfc.nasa.gov/Gauge/)

## Instrument Description

The UND Cessna Citation II Research Aircraft, used for the IPHEx field campaign, is owned and operated by the University of North Dakota. The Citation II is a twin-engine fanjet with an operating ceiling of 43,000 feet (13.1 km). The turbo fan engines provide sufficient power to cruise at speeds of up to 340 knots (175 m $s^{-1}$) or climb at 3,300 feet per minute (16.8 m $s^{-1}$). These high performance capabilities are accompanied by relatively low fuel consumption at all altitudes, giving the Citation II an on-station time of 3-5 hours, depending on the mission type. Long wings allow it to be operated out of relatively short

airstrips and to be flown at the slower speeds (140 kts/72 m $s^{-1}$) necessary for many types of measurements. The Citation II is certified for flight into known icing conditions. The research instrumentation on the Cessna Citation II aircraft are used to collect data for meteorology, cloud physics, air chemistry, and aerosol research. These instruments and some of their measured parameters are listed in Table 1. More information is available at the UND Cessna Citation II webpage.

Table 1: Instrument and measurements included

| Parameter Measured | Instrument | Instrument Description |
|---|---|---|
| State Parameters | Total Temperature Probe | Flight Level Temperature |
| | Pressure Transducer | Flight Level Pressure |
| | Cooled Mirror Hygrometer | Dew/Frost Point |
| | Laser Hygrometer | Dew/Frost Point Temperature |
| Winds and Turbulence | Gust Probe | Airspeed, Angles of Attack and Sideslip |
| | Pitot Tube | Airspeed, Turbulence |
| Cloud Imaging and Sizing | CDP | Cloud Droplet Concentration and Size |
| | PMS 2DC | Cloud Particle Imaging Probe |
| | Cloud Imaging Probe (CIP) | Cloud Particle Imaging Probe |
| | CPI | Small Cloud Particle Imaging Probe |
| | HVPS-3 | Precipitation Particle Imaging Probe |
| Water | King Probe | Liquid Water Content |
| | Nevzorov Probe | Liquid Water and Total Water Content |
| | Rosemount Icing Detector | Supercooled Liquid Water Presence and Content |
| | CSI | Total Water Content |
| Aerosols | CPC | Condensation Particle Counter |
| Aircraft | Applanix | Inertial Platform with Integrated GPS |

The complete list of measurements and associated instruments is available in the header block of the Quality Control processed data files. More information on Citation flight days can be found in the IPHEx Citation Mission Summary document.

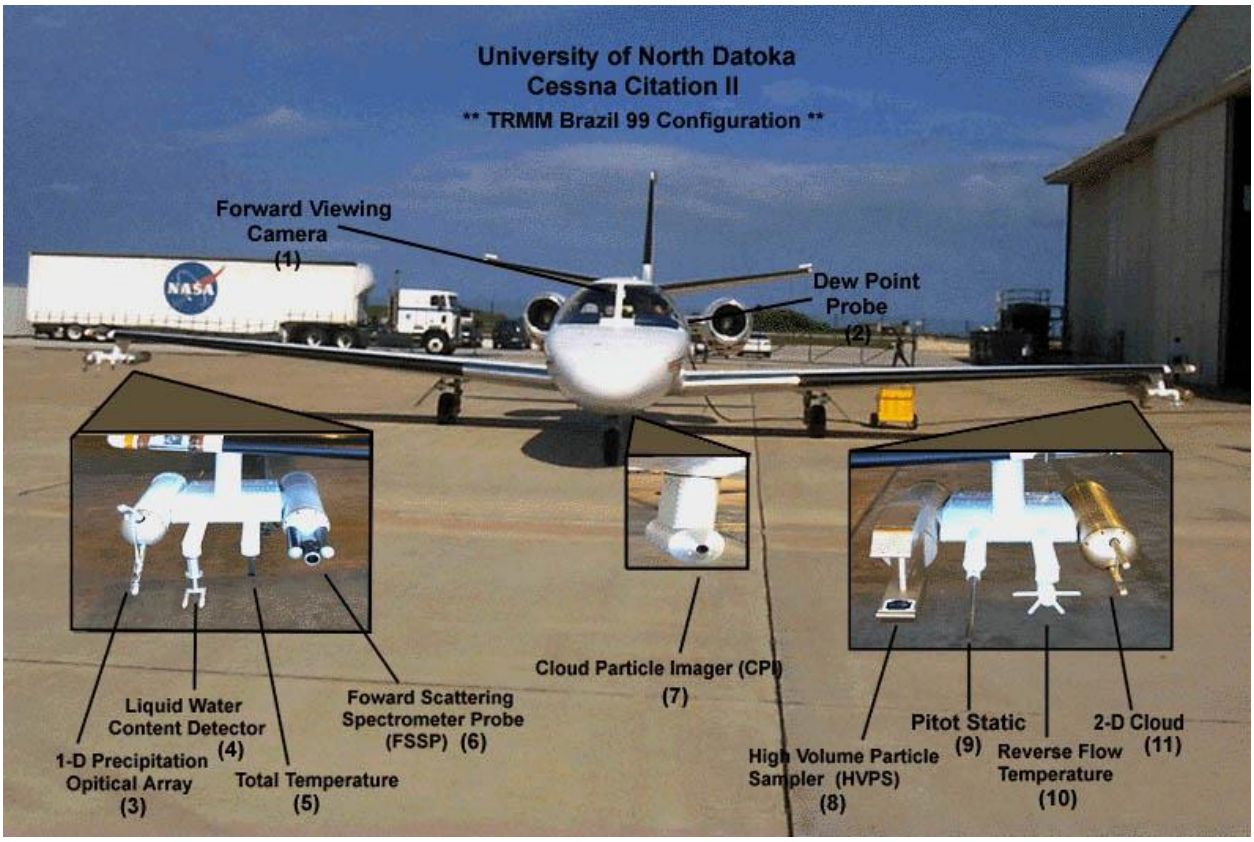


Figure 2: Cessna Citation II aircraft
(Image Source: UND Aerospace)

## Investigators

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## Data Characteristics

The GPM Ground Validation UND Citation Navigation Data IPHEx processing level 1A data are available in ASCII format. More information about the NASA data processing levels are available on the EOSDIS Data Processing Levels webpage.

Table 2: Data Characteristics

| Characteristic | Description |
|---|---|
| Platform | University of North Dakota (UND) Citation II aircraft |
| Instrument | Accelerometers, Global Navigation Satellite Systems (GNSS), GPS |
| Spatial Coverage | N: 46.5 , S: 43.5, E: -78.0, W: -81.0 (North Carolina) |
| Temporal Coverage | March 6, 2014 - June 13, 2014 |
| Temporal Resolution | Hourly - < Daily, One file per flight |
| Sampling Frequency | 1 second |
| Parameter | Navigation |
| Version | 1 |
| Processing Level | 1A |

## File Naming Convention

The GPM Ground Validation UND Citation Navigation Data IPHEx have the file naming convention shown below. The data files are available in ASCII format. The date and time of the file names are start time of the flight.

**Data files:** nav_YYYY_MM_DD_hh_mm_ss[.iphex|.Combined.iphex]

Table 3: File naming convention variables

| Variable | Description |
|---|---|
| YYYY | Four-digit year |
| MM | Two-digit month |
| DD | Two-digit day |
| hh | Two-digit hour in UTC |
| mm | Two-digit minute in UTC |
| ss | Two-digit second in UTC |
| [.iphex\|Combined.iphex] | .iphex or .Combined.iphex: Designates IPHEx project ASCII format file |

## Data Format and Parameters

The GPM Ground Validation UND Citation Navigation Data IPHEx dataset consists of ASCII data files. The files contain a header followed by rows of data. Table 4 defines each field, and additional information is available at the UND Citation Aircraft File Format webpage.

Table 4: Data Fields

| Field Name | Description | Unit |
|---|---|---|
| Time | UTC seconds from midnight on day aircraft flight started | UTC |
| Air_Temp | Air temperature corrected for Dynamic Heating (based first on the main temperature/pitot instrument and secondarily based on the backup temperature/pitot instrument) | degC |

| | | |
|---|---|---|
| MachNo_N | Mach number (based first on the main pitot instrument and secondarily based on the backup temperature/pitot instrument) | - |
| IAS | Indicated air speed (based first on the main pitot instrument and secondarily based on the backup pitot instrument) | m/s |
| TAS | True air speed (based first on the main temperature/pitot instrument and secondarily based on the backup temperature/pitot instrument) | m/s |
| Press_Alt | Pressure altitude | m |
| Pot_Temp_T1 | Potential temperature (based first on the main temperature/pitot instrument and secondarily based on the backup temperature/pitot instrument) | degK |
| Pitot_Wing | Pitot pressure from Wing Probe<br>(Calibration: slope = 207.08000<br>offset = -147.45550) | hPa |
| CABIN_PRES | Aircraft cabin pressure | mb |
| STATIC_PR | Static pressure<br>(Calibration: slope = 207.08000<br>offset = -0.71000000) | hPa |
| DEWPT | Dew point temperature from EG&G Probe<br>(Calibration: slope = 20.000000<br>offset = -70.000000) | degC |
| MixingRatio | Mixing ratio by weight from the Laser Hygrometer | ppmw |
| DewPoint | Dew point temperature from the Laser Hygrometer | degC |
| FrostPoint | Frost point temperature from the Laser Hygrometer | degC |
| POS_Roll | Aircraft roll angle from the Applanix Position and Orientation System POS<br>-180 to 180 range with 0 being level and positive angles in the clockwise (right) direction | degrees |
| POS_Pitch | Aircraft pitch angle from the Applanix Position and Orientation System (POS)<br>-180 to 180 range with 0 being level and positive angles in the clockwise (upward) direction away from center of the Earth | degrees |
| POS_Head | Aircraft heading angle from the Applanix Position and Orientation System (POS)<br>0 to 360 range with 0 being North and angles increasing in a clockwise (right) direction | degrees |
| POSZ_Acc | Aircraft z-direction (vertical) acceleration for the Applanix Position and Orientation System (POS) | $m/s^2$ |
| POS_Lat | Aircraft latitude from the Applanix Position and Orientation System (POS)<br>-90 to 90 range with positive values in Northern Hemisphere and negative values in Southern | degrees |

| | | |
|---|---|---|
| | Hemisphere | |
| POS_Lon | Aircraft longitude from the Applanix Position and Orientation System (POS)<br>-180 to 180 range with positive values in Eastern Hemisphere and negative values in Western Hemisphere | degrees |
| POS_Alt | Aircraft altitude from the Applanix Position and Orientation system (POS) | m |
| POS_Spd | Aircraft ground speed from the Applanix Position and Orientation System (POS) | m |
| POS_Trk | Aircraft track angle from the Applanix Position and Orientation System (POS)<br>0 to 360 range with 0 being North and angles increasing in a clockwise (right) direction | degrees |
| Alpha | Alpha (attack) angle<br>(Calibration: slope = 0.066317100<br>Offset = 0.40082229) | degrees |
| Beta | Beta (sideslip) angle<br>(Calibration: slope = -0.085875130<br>Offset = 0.16014451) | degrees |
| VERT_VEL | Vertical velocity of the aircraft based on the change in position over a 2-second interval | m/s |
| Wind_Z | Z (vertical) component of the wind speed (positive value is upward, away from the Earth's surface) | m/s |
| Wind_M | Horizontal wind speed | m/s |
| Wind_D | Horizontal wind direction<br>True direction from which it blows | degrees |
| TURB | Turbulence parameter (Eddy Dissipation Rate) based on Wing Pitot pressure | $cm^2/3*s^{-1}$ |
| King_LWC_ad | Liquid Water Content based on King Probe measurement adjusted (cloud threshold = 5.1 $\#/cm^3$, cloud interval = 30.0 s, and adjustment slope = 0.500) for the baseline offset | $g/m^3$ |
| Nev_TWC | Total Water Content based on the Nevzorov Probe measurement | - |
| Nev_LWC | Liquid Water Content based on the Nevzorov Probe measurement without correction for residual ice | - |
| CDP_Conc | Number concentration of droplets based on the Cloud Droplet Probe | #/cc |
| CDP_LWC | Liquid Water Content based on the Cloud Droplet Probe | $g/m^3$ |
| CDP_MenD | Cloud Droplet Probe's mean droplet diameter | um |
| CDP_VolDia | Cloud Droplet Probe's mean droplet volume diameter | um |
| CDP_EffRad | Cloud Droplet Probe's effective droplet radius | um |
| 2-DC_Conch | Number concentration of droplets based on the 2-DC | $\#/cm^3$ |

| | | |
|---|---|---|
| | Probe measurements for hydrometeors greater than 105 um | |
| 2-DC_MenDh | Mean droplet diameter based on the 2-DC Probe measurements for hydrometeors greater than 105 um | um |
| 2-DCVolDiah | Mean droplet volume diameter based on the 2-DC Probe measurements for hydrometeors greater than 105 um | um |
| 2-DCEffRadh | Effective droplet radius based on the 2-DC Probe measurements for hydrometeors greater than 105 um | um |
| IceMDOFreq | The current sensor (MSO) frequency from the Icing Detector | um |
| CPCConc | Total concentration from CPC | $\#/cm^3$ |
| TSG_Date | Date stamp based on data file name (Example: 941119 is 19 November 1994) | stamp |
| CSI_M_Ratio | Mixing ratio by volume from the CSI Laser Hygrometer without external calibration applied | $g/m^3$ |
| CSI_CWC | Cloud Water Content with correction from the CSI probe | $g/m^3$ |
| Nt2DSHGT105 | TwoDS H total normalize particle concentration of particles greater than 105 microns | $\#/m^3$ |
| Nt2DSH_all | TwoDS H total normalize particle concentration for all bin sizes | $\#/m^3$ |
| Nt2DSVGT105 | TwoDS V total normalize particle concentration of particles greater than 105 microns | $\#/m^3$ |
| Nt2DSV_all | TwoDS V total normalize particle concentration for all bin sizes | $\#/m^3$ |
| Nt_HVPS3V | HVPS3 V total normalize particle concentration for all bin sizes | $\#/m^3$ |

## Software

No software is required since these data are available in ASCII format.

## Known Issues or Missing Data

There is one file per UND Citation aircraft flight. Since flights do not occur on a regular basis during the field campaign, there are missing days between March 6, 2014 and June 13, 2014.

## References

Barros, A. P., Petersen, W., Schwaller, M., Cifelli, R., Mahoney, K., Peters-Liddard, C., … Kim, E. (2014). NASA GPM-Ground Validation: Integrated Precipitation and Hydrology Experiment 2014 Science Plan, *12*. https://doi.org/10.7924/G8CC0XMR

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University of North Dakota John D. Odegard School of Aerospace Sciences. (2015). Cessna Citation II Research Aircraft. http://airborneresearch.atmos.und.edu/

University of North Dakota John D. Odegard School of Aerospace Sciences. (2015). Data File Format. http://airborneresearch.atmos.und.edu/dataformat.aspx

## Related Data

All data from other instruments collected during the IPHEx field campaign are related. Other IPHEx campaign data can be located using HyDRO 2.0 with the search term "IPHEx". The complete IPHEx field campaign data collection is available here. Other related datasets for the UND Citation aircraft are listed below.

GPM Ground Validation UND Citation Cloud Microphysics IPHEx
(http://dx.doi.org/10.5067/GPMGV/IPHEX/MULTIPLE/DATA201)

GPM Ground Validation Citation Videos IPHEx
(http://dx.doi.org/10.5067/GPMGV/IPHEX/CAMERA/DATA101)

In addition, UND Citation Navigation was used in previous GPM GV field campaigns. The following datasets are UND Citation Navigation data from other field campaigns:

GPM Ground Validation UND Citation Navigation Data OLYMPEX
(http://dx.doi.org/10.5067/GPMGV/OLYMPEX/NAV/DATA101)

GPM Ground Validation UND Citation Navigation Data MC3E
(http://dx.doi.org/10.5067/GPMGV/MC3E/NAV/DATA102)

GPM Ground Validation UND Citation Navigation Data GCPEx V2
(http://dx.doi.org/10.5067/GPMGV/GCPEX/NAV/DATA002)

## Contact Information

To order these data or for further information, please contact:

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